

CLAIMS

What is claimed is:

1. A system comprising:
 - a first light emitting diode having an epitaxial structure comprising an active region sandwiched between an n-type region and a p-type region, the active region configured to emit light that is at least 50% polarized along a first polarization orientation when forward biased; and
 - a microdisplay disposed in a path of light emitted by the active region from the first light emitting device.
2. The device of Claim 1, wherein the active region is configured to emit light that is at least 80% polarized.
3. The device of Claim 1, wherein the active region comprises at least one layer of $\{11\bar{2}0\}$ InGaN.
4. The device of Claim 1, wherein the active region comprises at least one layer of $\{10\bar{1}0\}$ InGaN.
5. The system of Claim 1, wherein the microdisplay is a polarized microdisplay.
6. The system of Claim 1, further comprising:
 - a second light emitting diode having an epitaxial structure comprising an active region sandwiched between an n-type region and a p-type region, the active region of the second light emitting diode configured to emit light that is at least 50% polarized along a second polarization orientation when forward biased;
 - a polarizing beamsplitter disposed in the path of the light having a first polarization orientation emitted by the first light emitting diode and light having a second polarization orientation emitted by the second light emitting diode, wherein the

polarizing beamsplitter combines the light having a first polarization orientation and the light having a second polarization orientation; and

wherein the microdisplay receives the light having a first polarization orientation and the light having a second polarization orientation after being combined by the polarizing beamsplitter.

7. The system of Claim 6, wherein the first polarization orientation is orthogonal to the second polarization orientation.

8. The system of Claim 6, wherein the polarizing beamsplitter has a first entrance surface, a second entrance surface and an exit surface, the first light emitting diode being coupled to the first entrance surface and the second light emitting diode being coupled to the second entrance surface, the system further comprising:

a concentrator member having an entrance surface coupled to the exit surface of the polarizing beamsplitter, the concentrator member having an exit surface that has a smaller area than the entrance surface of the concentrator member, wherein light from the beamsplitter enters the concentrator member through the entrance surface and is emitted from the exit surface of the concentrator member; and

a wavelength converting element coupled to the concentrator member.

9. The system of Claim 8, wherein more than half of the light that enters the concentrator member through the entrance surface is emitted through the exit surface of the concentrator element.

10. The system of Claim 8, wherein the concentrator member is a compound parabolic concentrator.

11. The system of Claim 8, wherein the concentrator member comprises a transparent element coupled to the polarizing beamsplitter, the transparent member having reflective surfaces that define the exit surface.

12. The system of Claim 11, wherein the reflective surfaces are formed from a reflective material overlying a portion of the transparent member.

13. The system of Claim 11, wherein the reflective surfaces are formed from sidewalls of the transparent member.

14. The system of Claim 8, wherein the concentrator member is formed from a cavity within a solid body.

15. The system of Claim 8, wherein the wavelength converting element is disposed on the exit surface of the concentrator element.

16. The system of Claim 8, wherein the wavelength converting element is a phosphor layer.

17. The system of Claim 8, further comprising a polarizing element disposed on the wavelength converting element, wherein the wavelength converting element is disposed between the polarizing element and the polarizing beamsplitter.

18. An apparatus comprising:

an epitaxial structure comprising an active region sandwiched between an n-type region and a p-type region, the active region configured to emit light when forward biased;

a non-absorbing polarizer coupled to the active region, the non-absorbing polarizer transmitting light having a desired polarization orientation and reflecting light that does not have the desired polarization orientation; and

a randomizing element coupled to the active region and the non-absorbing polarizer, the randomizing element positioned to receive light emitted from the active region and reflected from the non-absorbing polarizer, the randomizing element at least partially randomizes the polarization state of the light.

19. The apparatus of Claim 18, wherein the non-absorbing polarizer is a wire grid polarizer.
20. The apparatus of Claim 18, wherein the randomizing element is a wavelength converting material disposed between the non-absorbing polarizer and the active region.
21. The apparatus of Claim 20, wherein the wavelength converting material is a phosphor.
22. The apparatus of Claim 18, wherein the randomizing element is a roughened surface that scatters light.
23. The apparatus of Claim 21, wherein the apparatus is a light emitting diode that further comprises a substrate, wherein a surface of the substrate is the roughened surface that is disposed between the non-absorbing polarizer and the active region.
24. The apparatus of Claim 18, wherein the randomizing element is a birefringent material.
25. The apparatus of Claim 18, further comprising:
a transparent member having an entrance surface coupled to the active region to receive light emitted by the active region, the transparent member having reflective surfaces that define an exit surface through which light exits the transparent member, wherein the exit surface is smaller than the entrance surface and wherein the transparent member is shaped such that light emitted from the active region is directed toward the exit surface;
wherein the non-absorbing polarizer is coupled to the transparent member and is positioned over the exit surface and the randomizing element is disposed between the non-absorbing polarizer and the active region.
26. The apparatus of Claim 25, wherein the transparent member forms a compound parabolic concentrator.

27. The apparatus of Claim 25, wherein the reflective surfaces are formed from a reflective material overlying a portion of the transparent member.

28. The apparatus of Claim 27, further comprising a dielectric layer disposed between the transparent member and reflective material.

29. The apparatus of Claim 25, wherein the reflective surfaces are formed from sidewalls of the transparent member.

30. The apparatus of Claim 25, further comprising a dichroic filter disposed between the randomizing element and the non-absorbing polarizer.

31. The apparatus of Claim 25, further comprising a second non-absorbing polarizer, the second non-absorbing polarizer being disposed between the randomizing element and the active region.

32. The apparatus of Claim 18, further comprising a microdisplay disposed in a path of light transmitted by the non-absorbing polarizer.

33. The apparatus of Claim 32, wherein the microdisplay is a polarized microdisplay.

34. The apparatus of Claim 32, further comprising:

a second epitaxial structure comprising a second active region sandwiched between a second n-type region and a second p-type region, the second active region configured to emit light when forward biased;

a second non-absorbing polarizer coupled to the second active region, the second non-absorbing polarizer transmitting light having a second polarization orientation that is orthogonal to the polarization orientation of the light transmitted by the non-absorbing polarizer, and reflecting light that does not have the second polarization orientation;

a second randomizing element coupled to the second active region and the second non-absorbing polarizer, the second randomizing element positioned to receive light emitted from the second active region and the second non-absorbing polarizer, the second randomizing element at least partially randomizes the polarization state of the light; and

a polarizing beamsplitter disposed in the path of the light transmitted by the non-absorbing polarizer and the light transmitted by the second non-absorbing polarizer, wherein the polarizing beamsplitter combines the light transmitted by the non-absorbing polarizer and the light transmitted by the second non-absorbing polarizer;

wherein the microdisplay receives the combined light from the polarizing beamsplitter.

35. The apparatus of Claim 32, wherein the active region is a first active region in a first light emitting diode, the apparatus further comprising:

a second light emitting diode having a second epitaxial structure comprising a second active region sandwiched between a second n-type region and a second p-type region, the second active region configured to emit light when forward biased;

a polarizing beamsplitter has a first entrance surface, a second entrance surface and an exit surface, the first light emitting diode being coupled to the first entrance surface and the second light emitting diode being coupled to the second entrance surface, wherein the polarizing beamsplitter combines the light emitted by the first light emitting diode and the light emitted by the second light emitting diode;

a concentrator member having an entrance surface coupled to the exit surface of the polarizing beamsplitter, the concentrator member having an exit surface that has a smaller area than the entrance surface of the concentrator member, wherein light from the beamsplitter enters the concentrator member through the entrance surface and is emitted from the exit surface of the concentrator member;

wherein the non-absorbing polarizer is coupled to the concentrator member and is positioned over the exit surface and the randomizing element is disposed between the non-absorbing polarizer and the concentrator member.

36. An apparatus comprising:

a light emitting diode;

a transparent member having an entrance surface coupled to the light emitting diode, the transparent member having reflective surfaces that define an exit surface through which light exits the transparent member, wherein the exit surface is smaller than the entrance surface and wherein the transparent member is shaped such that light emitted from the light emitting diode is directed toward the exit surface; and

a wavelength converting material coupled to the transparent member.

37. The apparatus of Claim 36, wherein the transparent member is a compound parabolic concentrator.

38. The apparatus of Claim 36, wherein the reflective surfaces of the transparent member are formed from a reflective material overlying a portion of the transparent member.

39. The apparatus of Claim 38, further comprising a dielectric layer disposed between the transparent member and reflective material.

40. The apparatus of Claim 38, wherein the reflective material is a metal.

41. The apparatus of Claim 40, wherein the metal has a reflectance greater than 90%.

42. The apparatus of Claim 40, wherein the metal is selected from the group consisting of silver, gold, aluminum, and rhodium.

43. The apparatus of Claim 36, wherein the reflective surfaces of the transparent member are formed from sidewalls of the transparent member.

44. The apparatus of Claim 36, wherein the transparent member is selected from the group consisting of sapphire, glass, acrylic, silicone, and epoxy.

45. The apparatus of Claim 36, further comprising a dichroic filter disposed between the wavelength converting material and the light emitting diode.

46. The apparatus of Claim 36, further comprising a polarization filter disposed between the wavelength converting material and the light emitting diode.

47. The light emitting device of Claim 46, wherein the polarization filter is a wire-grid polarizer.

48. The apparatus of Claim 36, further comprising a dichroic filter coupled to the wavelength converting material, wherein the wavelength converting material is disposed between the dichroic filter and the light emitting diode.

49. The apparatus of Claim 36, further comprising a polarization filter coupled to the wavelength converting material, wherein the wavelength converting material is disposed between the polarization filter and the light emitting diode.

50. The apparatus of Claim 49, wherein the polarization filter is a wire-grid polarizer.

51. The apparatus of Claim 36, wherein the wavelength converting material is disposed on the exit surface.

52. The apparatus of Claim 36, wherein the wavelength converting material is a phosphor.

53. The apparatus of Claim 36, further comprising an optical system positioned near the exit surface.

54. The apparatus of Claim 53, wherein the optical system comprises a microdisplay.

55. The apparatus of Claim 36, wherein the light emitting diode is a first light emitting diode with an epitaxial structure comprising an active region sandwiched between an n-type region and a p-type region, the active region configured to emit light that is at least 50% polarized along a first polarization orientation when forward biased, the apparatus further comprising:

- a second light emitting diode with an epitaxial structure comprising an active region sandwiched between an n-type region and a p-type region, the active region of the second light emitting diode configured to emit light that is at least 50% polarized along a second polarization orientation when forward biased; and

- a polarizing beamsplitter disposed between the first light emitting diode and the transparent member, the polarizing beamsplitter configured to receive light from the first light emitting diode and light from the second light emitting diode, wherein the polarizing beamsplitter combines the light having a first polarization orientation and the light having a second polarization orientation and emits the combined light to the entrance surface of the transparent member.

56. The apparatus of Claim 55, wherein the first polarization orientation is orthogonal to the second polarization orientation.

57. A light emitting device comprising:

- a light emitting diode;

- a concentrator element coupled to the light emitting diode, the concentrator element having an entrance surface coupled to receive light emitted by the light emitting diode, and an exit surface that is smaller than the entrance surface, the concentrator element being shaped such that light received at the entrance surface is directed toward the exit surface; and

a wavelength converting material disposed over the exit surface.

58. The light emitting device of Claim 57, wherein the concentrator element is configured to approximately preserve the radiance of the light emitting diode.

59. The light emitting device of Claim 57, wherein the wavelength converting material is a phosphor.

60. The light emitting device of Claim 57, wherein the concentrator element is a compound parabolic concentrator.

61. The light emitting device of Claim 57, further comprising at least one of a dichroic filter and a polarization filter disposed between the wavelength converting material and the concentrator element.

62. The light emitting device of Claim 61, wherein the polarization filter is a wire-grid polarizer.

63. The light emitting device of Claim 57, further comprising at least one of a dichroic filter and a polarization filter coupled to the wavelength converting material and the concentrator element, wherein the wavelength converting material is disposed between the light emitting diode and the at least one of a dichroic filter and a polarization filter.

64. The light emitting device of Claim 63, wherein the polarization filter is a wire-grid polarizer.

65. The light emitting device of Claim 57, further comprising an optical system positioned near the exit surface.

66. The light emitting device of Claim 57, wherein the optical system comprises a microdisplay.

67. The light emitting device of Claim 57, wherein the concentrator element is formed from a transparent member having reflective surfaces that define the exit surface.

68. The light emitting device of Claim 67, wherein the reflective surfaces are formed from a reflective material overlying a portion of the transparent member.

69. The light emitting device of Claim 67, wherein the reflective surfaces are formed from sidewalls of the transparent member.

70. The light emitting device of Claim 57, wherein the concentrator element is formed from a cavity within a solid body.